In addition, the disaster recovery plan of distributed virtual SAN infrastructure can be flexibly implemented as showing in Fig. 10. With this recovery plan, the host 1 or 3 (1 of Fig. 10) can continue to operate whenever one of its mirrored IP SAN units failed (3 of Fig. 10). Also, the spare IP SAN unit can be used to quickly replace the failed IP SAN unit whenever there is needs. On the other hand, the hosts (1 of Fig. 10) also can be organized into a service pool such as for distributing video service, distributed database pool, distributed security monitor services, and all other services provided on net and on Web. Therefore, whenever host 1 or 3 failed, the spare host can quickly take over their assigned IP SAN storage and replace them to continue provide service to the end user.

What is claimed is:

A Method of Configuring a Distributed Virtual SAN for Hosts Accessing.

1: The IP based out-band accessed Distributed Scalable Virtual SAN is a new scheme for IP based storage system and it consists of

a) Multiple IP SAN units.

b) Distributed control and management station.

c) Network interconnecting infrastructure.

d) Storage management console.

This virtual SAN can be accessed by

e) Hosts.

- IP SAN Unit:

2: The method of claim 1, item a) further includes

- IP SAN unit runs with operating system such as Linux, various Unix, MS Window, real-timed OS, or others.
- It contains IP SAN services software modules, which is able to provide management services to distribute control management station through IP

based or non-IP based protocols, and to provide block data service to one or more hosts through IP based communication protocols.

- The service software modules on IP SAN unit could be implemented with any suitable programming languages such as C, C++, Java, XML or others.

3: The method of claim 1, item a) further includes

- A Fibre Channel Based SAN unit can appear as an IP based SAN, as long as a Fibre Channel to IP gateway used to translate the protocol between Fibre Channel and IP.

4: The claim 1, wherein, item a) further includes

- Each IP SAN unit must contain the storage media, which could be magnetic disk drive, optical disk drive, solid state disk drive, or memory cards and the related storage control media.
- Each IP SAN unit must contains the network connection media, which could be the controller of either Ethernet, or other media, which support IP based protocol.
- Fibre Channel based SAN or other SAN may contain Fibre Channel or other connection media.

- The Control Management Station:

5: The method of claim 1, wherein, item (b) further includes

a) The control management station contains control management software modules, which communicate with service software modules of IP SAN unit through suitable IP or non-IP based protocols. Therefore, it can get and store all necessary information of each IP SAN units, to provide control, monitor, and management for multiple IP SAN units, and to construct virtual storage pool.

b) The control management software also can communicate to the service software modules on hosts and hence to provide control, monitor, and

management for hosts through suitable IP based or non-IP based protocols.

c) The control management software modules can be implemented with any suitable programming languages such as C, C++, Java, XML etc.

6: The method of claim 1, wherein, item (b) further includes

a) The control management station contains console support software modules and web server software, which communicate with console software (web browser) of console host to provide full ranges of multiple concurrent system operations and tasks for entire distributed virtual SAN storage system as well as for each hosts.

b) The console support software modules of control management station communicate with control management software modules and with web server software modules through inter-process communication on native control management station.

c) The console support software can be implemented with any suitable programming languages such as C, C++, Java, XML etc. The web server software could be any off the shelf commercial software or a proprietary software which uses web protocol such as HTTP communication protocol.

d) If non-web based console supported, there is no need for web server software module on control management station. In this case, the console support software modules must be capable to communicate with console software of console host by using protocol other than web protocol (HTTP).

7: The method of claim 1, wherein, item (b) further includes

- The control management station could be a server, desktop or laptop PC, or a communication system, or a device, which is able to control, manage large number of IP SAN units and hosts.
- The control management station has operating system running such as Linux, various Unix, MS Window, real-time OS, or others.

- **The Network Interconnecting Infrastructure:**

8: The method of claim 1, wherein, item c) further includes

a) Network infrastructure represents any kind of communication link, which connects control management station, IP SAN units, and hosts together.

b) It consists communication system such as switches, routers or gateways, and it also consists with network cable (Fibre optical or cat5, or other cable) or wireless connection media.

c) In order for the distributed virtual SAN units, control management station and hosts be operated not only in single domain environment but also in a cross network domains environment, the network address identification software infrastructure such as DNS or others is required.

- **Management Console on Console Host:**

9: The method of claim 1, wherein, item d) further includes

- The management console is a software, which could be an off the shelf commercial web browser running on console host and using web protocol such as HTTP.
- The console host could be a server, desktop or laptop PC, or a communication system, or a device. It could be an independent system anywhere on the net or just is the control management station itself. There may be multiple console hosts and each one has a storage management console software.
- The management console software communicates with console support software modules and web server software on control management station. It is able to obtain information of entire distributed virtual SAN infrastructure and to allow user to perform concurrent multiple simultaneous tasks and operations on entire IP SAN units of this distributed virtual SAN and on hosts.
- To support non-Web based console, instead of using web browser, a special console software module is required, which shall be able to

communicate with console support software modules of control management station by using protocols other than web protocol (HTTP). This special console software could be implemented with any suitable programming languages.

The Hosts:

10: The claim 1, further includes

- Hosts contain service software modules, which allow it to communicate with control management station through suitable IP based protocol or any suitable non-IP protocols to get necessary storage information within entire distributed virtual SAN. In addition, the service software also can perform various tasks on hosts in responding to the tasks assigned by control management station and issued from web-console.
- Th service software modules also communicate with service modules of IP SAN unit directly through suitable IP based protocols to access the block data of any IP SAN unit after that storage volume being assigned by the control management station.
- The service software modules on host could be implemented with any suitable programming languages such as C, C++, Java, XML etc.
- The hosts could be a server, desktop or laptop PC, or a communication system, or a device, which can communicate to IP SAN units utilize the block data provide by IP SAN unit.
- The host has operating system running such as Linux, various Unix, MS Window, real-time OS, or others.

The Method of Virtual SAN Storage Pool Automatic Construction Either in a Single Network Domain or in Cross Network Domains Environment:

11: The Virtual SAN Storage Pool can be automatically configured and built in a single network domain or in cross network domains environment based on:

a) "Virtual SAN storage pool automatic configuration protocol"

b) The IP address identification software such as DNS (domain name server) software in the network infrastructure.

12: The methods of claim 11, wherein, item a) further comprises protocol sequence for automatic constructing storage pool of distributed virtual IP SAN:

1) When any of IP SAN units brought up to online, its SAN service modules sent out a "SAN unit (n) startup" packet to distribute control management station.
2) When distribute control management modules of distribute control management station receives IP SAN unit (n) message, it stores the IP SAN unit (n)'s information. It then sends back a "need SAN unit (n)'s storage info" packet to IP SAN unit (n).
3) When SAN service modules on IP SAN unit (n) received the packet of "need SAN unit (n)'s storage info", it gets storage information on IP SAN unit (n), and then send back a packet of "unit (n) storage info", which includes all information it obtained to distribute control management station.
4) After receiving "unit (n) storage info" packet from IP SAN unit (n), the distribute control management modules on distribute control management station updates its stored IP SAN units with corresponding storage information of IP SAN unit (n) from packet.

13: The methods of claim 11, wherein, item a) further comprises protocol sequence for update storage pool of distributed virtual SAN when any IP SAN unit shuts down:

- When any IP SAN unit (n) shutting down, the service module of IP SAN unit (n) sends "Unit (n) shutdown" to distribute control management station.
- After received "unit (n) shutdown" packet from IP SAN unit (n), the distribute control management modules on distribute control management

station updates the stored information for that specific of IP SAN unit (n) and for the distributed IP SAN virtual storage pool.

14: The claim 12, wherein, item 2), 3) and 4) further includes

- The "storage info" in packet includes the number of storage volumes, each volume's start address (logical block address, LBA), volume size, and the end address (logical block address, LBA) of each volume etc.

15: The method of claim 11, wherein,

Item a) further includes the "Virtual SAN automatic configuration protocol" be executed at the time of IP SAN unit system startup (boot up) if the IP SAN unit was powered off, or at the time of network link bring up if the IP SAN unit's network link was down.

Item a) further requires the "Virtual SAN automatic configuration protocol" be executed at IP SAN unit shutdown time.

16: The method of claim 11, wherein, item a) further clarify

- "Virtual SAN automatic configuration protocol" could be an UDP/IP based protocol or any suitable IP based protocol with same protocol scenario and sequence for boot-up and shutdown.

17: The method of claim 11, wherein, item a) further clarifies

- the startup packet, which sent by IP SAN unit to distribute control management station, could be a SNMP trap of cold start, a SNMP trap of link up, or a much simple UDP packet.

18: The method of claim 11, wherein, item a) further clarifies

- The shutdown packet, which sent by IP SAN unit to distributed control management station, could be a SNMP trap of link down or a much simple UDP packet, which indicates a system down.

Method of Supporting Storage Volumes on Demanding:

19: The claim 11 further includes that the virtual storage pool of entire distributed virtual SAN can provide storage service on demanding to all hosts:

a) From the management console, the entire virtual storage pool can be configured, partitioned, and each volumes on any IP SAN units can be assigned to each individual hosts based on demand.

b) Based on assigned information, each hosts can directly negotiate with assigned IP SAN unit and further to directly access the assigned storage volumes of IP SAN unit without go through control management station.

Dynamic Capacity Expanding:

20: The claim 12, claim 13 and together with claim 19 item b) further includes and evidenced

a) The entire virtual storage pool can be dynamically expanded and updated without interrupting the normal storage operating and accessing.

b) At any time an idle IP SAN unit can be brought into virtual storage pool or a not used IP SAN unit in the pool can be brought down while other IP SAN units in the storage pool are being accessed or configured.

Scalability:

21: The claim 19 and claim 20 further include and evidence

a) Each host can request and be assigned with multiple storage volumes partitions on multiple different IP SAN units in the storage pool, and further to access them.

b) The virtual storage pool can guarantee to have spare storage volumes due to any new IP SAN unit can be brought into virtual storage pool at any time whenever there is demand.

c) Each host can guarantee to expand and scales up its storage system dynamically by requesting spare storage volumes in the virtual storage pool.

d) This out-band accessed distributed virtual SAN provides a far better scalability than the in-band accessed virtual SAN due to the scalability of in-band accessed virtual SAN were severely limited by the bottlenecked control management station

Storage Sharing:

22: The claim 19 further includes that the storage of each single IP SAN unit in virtual storage pool of distributed virtual SAN can be shared by multiple hosts.

a) Each IP SAN unit in virtual storage pool can be configured and partitioned with multiple volumes and to be assigned to multiple hosts.

b) With block data service modules' support on each IP SAN unit in distributed virtual SAN, when multiple hosts have been assigned volumes on a same IP SAN unit, each host can exclusively access assigned volume on the same IP SAN unit simultaneously.

Performance:

23: The claim 19, wherein, item b) further includes that out-band accessed distributed virtual SAN provides better performance than the in-band accessed virtual SAN.

a) With distributed virtual SAN of this invention each hosts can directly and independently accessing any IP SAN unit without go through control management station.

b) Unlike in-band accessed virtual SAN, with out-band accessed distributed virtual SAN, the control management station will not be a performance bottleneck.

Disaster Recoverability:

24: The claim 8, wherein, item c) further includes that the operation of distributed IP SAN infrastructure in cross network domains environment allow a much powerful disaster recovery plan to be implemented.

- Any IP SAN unit (including mirrored or spared) or host (including spared) as well as control management station could be anywhere on corporate Intranet, on Internet or on LAN, therefore, it is possible to have a disaster recoverability plan goes beyond 100 miles long vs traditional 10 kilometer limitation.

25: The claim 21, wherein, item a) further includes

- The IP based distributed virtual SAN infrastructure can provide multiple hosts each with a pair of mirrored IP SAN units, therefore, whenever one of mirrored IP SAN unit had broken, the host own that pair of mirrored IP SAN units can continue to operate normally without stopping.
- The IP based distributed virtual SAN infrastructure also can keep certain ratio of spared IP SAN unit. Therefore, whenever a mirrored IP SAN unit is broken, the spared IP SAN unit can replace the broken one if there is needs.

Centralized Management of Distributed Virtual SAN Infrastructure:

26: The claim 9 further includes that the support of management console of this distributed virtual SAN infrastructure provides centralized management functionality for all IP SAN units, control management station and all hosts within this infrastructure.

- With multiple concurrent tasks supporting in console support software modules of control management station, from the management console, user can issue a full range of multiple concurrent system operations and tasks throughout the entire distributed virtual SAN and hosts.
- The management tasks includes storage configuration, storage volume allocation and assignment, storage partition and repartitioning, resource and activity monitoring for storage, network, all hosts and others etc..

The Security:

27: The claim 26 further includes that management capability of control management station also includes the security management at multiple levels.

- It is to provide security protection at control management station level, at IP SAN unit level, or may be at hosts level.

28: The claim 27 and the claim 19, wherein, item b) further include

- At control management level, it provides security authentication for the user from management console such as provide password mechanism and provide security screening to determine a specific task or operation is allowed for a specific user and for a specific IP SAN or host system.
- At IP SAN unit level, it provides mechanism to determine if a particular host is permitted to access storage volume on a particular IP SAN unit during negotiation process.

29: The claim 28, claim 27 further include

Similar security may impose on host systems.

Non-IP Based SAN:

30: To let IP SAN unit to work in a non-IP network environment, the IP SAN unit must be capable to support non-IP based protocol or the IP SAN units may be replaced by other type of SAN unit, which support non-IP based protocol. All claims, which described previously can apply to non-IP based distributed virtual SAN infrastructure.

The Application of Automatic Construction of Virtual Storage Pool for Other Distributed Scalable Virtual Machine:

31: The methods of claim 11, 12, and 13 further include:

- The method and principle of automatic constructing virtual storage pool of the distributed virtual SAN infrastructure can be applied to other type of distributed virtual machine in forming multiple different type of resource pools and multiple different type of application service pools. For example, they could be Web service pool, video service pool, security monitor service pool, database service pool etc.

32: The claim 14 and claim 31 further include

- To effectively apply the methods and principles of automatic constructing virtual storage pool of this invention to other type of distributed virtual machine, the IP SAN units my be replaced by other type of system units. In addition, the "storage info" in the packet may be replaced with other type of information, which specifically can be used by other type of distributed virtual machine to construct different type of service pool.
- These different type of application service pools or resource pools of the distributed virtual machine will have similar advantages, which have been described previously such as dynamic capacity expanding, scalability, performance, disaster recoverability, security, centralized management and support service on demanding, etc.

33: The claim 26 further includes

- The ability of managing for a group of hosts and the ability to organize virtual service pool will allow console support software and control management software of control management station to organize hosts into one or more other type of service pools. Further, these service pools can provide services to client systems on the net.

The Software Modules of Central Controlled Distributed Scalable Virtual Machine System:

34: The claims1 through claim 33 further include that

- The software modules of IP based out-band-accessed distributed virtual SAN infrastructure have combined the Web technology, network and system management technology, and the distributed clustering system technology together. They include console support software modules and control management software modules on control management station, the service software modules on IP SAN unit as well as web server software.

- The software modules of IP based out-band-accessed distributed virtual SAN infrastructure actually forms a basic model of Web-Based virtual operation system for central controlled distributed scalable virtual machine (CCDSVM) because of its ability to support configure resource, support concurrent multi-tasks, and deliver services over entire virtual machine.

35: The claim 26, and 34 further includes

- This virtual operating system of distributed virtual machine can effectively provide streamlined operations for all systems such as from managing, configuring storage and other resources, managing network, and delivering different services or contents to other client systems on the net.

36: The claim 6 and claim 9 further includes that

- If there is needs, a less effective non-web-based console can be built for all type of CCDSVM by replacing web server software on control management station with a network communication software module and replacing web browser on console host with another network communication software.

37: The claim 8, wherein, item c) and claim 11, wherein, item b) further includes

- Without Internet address identification software infrastructure such as DNS, the IP based out-band accessed distributed virtual SAN or other CCDSVM system may be degenerate to work in LAN environment only.
- In LAN environment, other IP address identification mechanism may be used such as DHCP etc.

38: The claim 15, claim 16 and claim 33 further includes

- A less inter-operative, less compatible distributed virtual SAN or other CCDSVM system can be built if using non-IP based protocol with all software modules described in this invention.